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REVIEW

Multimodal analgesic strategies in polytraumatized patients

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ABSTRACT

In recent years, the resuscitation of trauma patients has improved; however, pain related to trauma remains associated with systemic complications. In trauma patients, pain should be considered a vital sign, and its control is crucial for reducing complications, improving patient satisfaction, and enhancing the quality of life. The multimodal analgesia approach is the mainstay in pain control, and growing evidence in the literature supports a greater role of regional anesthesia in the management of trauma casualties. In this review, we offer the reader an updated general framework of the various approaches available for pain treatment in polytraumatized patients, with a focus on the opportunities presented by regional anesthesia. We will examine different types of locoregional anesthesia blocks and describe ultrasonographic execution techniques.

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KEY WORDS: Analgesia; Conduction anesthesia; Nerve block.

Polytrauma patients represent about 25% of major trauma admissions,[1] and it is the most crucial factor related to death for patients under 45 years of age in industrialized countries.[2] Falls, burns, violence, and road accidents are among the most significant causes of pain in polytraumatized patients, as declared by the World Health Organization.[3] In recent years, the resuscitation of trauma patients has improved thanks to the Advanced Trauma Life Support algorithm, but pain remains untreated in trauma patients and is associated with severe complications.[4] Indeed, pain in polytraumatized patients triggers the activation of stress responses, including the Hypothalamic-Pituitary-Adrenal axis and the autonomous Sympathetic Nervous System (SNS). This results in excessive release and production of catecholamines in the adrenal medulla immediately after trauma. Elevated levels of catecholamines in serum and increased SNS tone can lead to complications in multiple systems.[5, 6] The European Society for Emergency Medicine guidelines state that between 60 and 90% of patients admitted to the emergency department (ED) report pain.[7] Over the years, various treatments to alleviate pain in trauma patients have been adopted, such as the early use of analgesic drugs (morphine, fentanyl, etc.) or light sedation (midazolam, ketamine, etc.). However, the approach to pain management is often still inconsistent and, in some cases, very superficial.[8] The reasons for inadequate pain control in trauma

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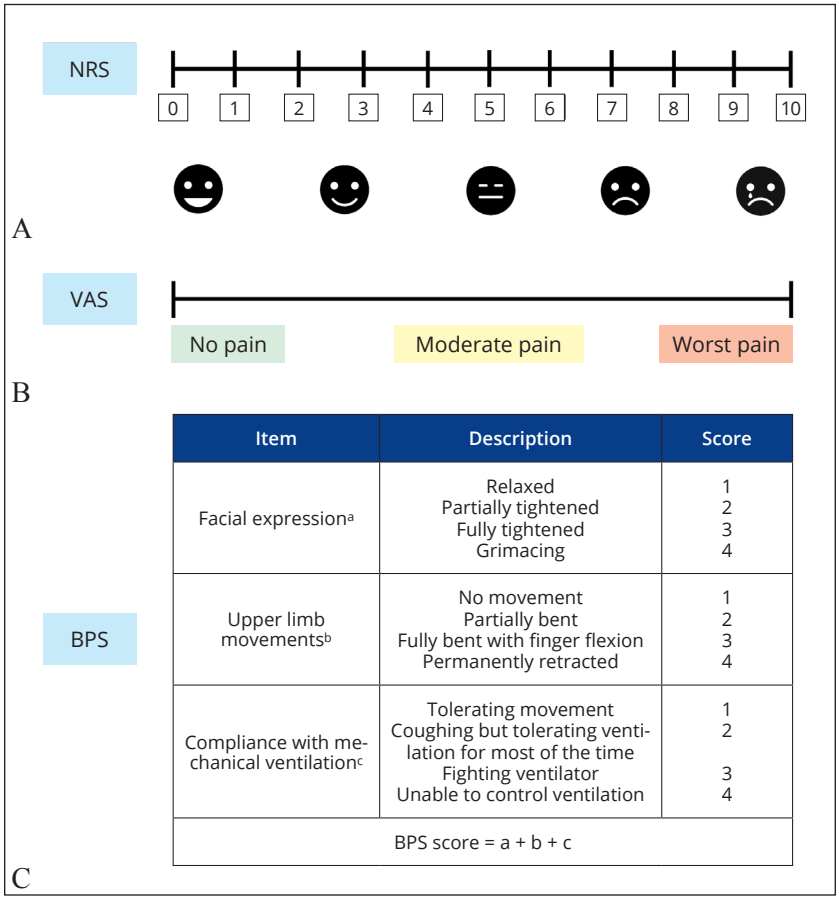
patients are not fully understood. Misinterpretation of pain intensity, challenges in assessing and quantifying pain due to altered vital parameters linked to trauma, and difficulties in balancing the stability of vital parameters, pharmacological therapy, and concerns about the adverse effects of analgesic drugs make this issue a "hot topic" in modern literature.[9, 10] Other barriers associated with inadequate pain management are linked with deficient infrastructure and service settings, such as the overcrowding of the ED or differences in protocols and guidance, and training of healthcare workers.[7, 11]

The recognition and alleviation of pain should commence at triage and should be monitored throughout hospitalization, ensuring adequate analgesia for the entire hospital stay and after hospital discharge.

The review aims to provide the reader with an updated general framework on the different approaches available for pain treatment in polytraumatized patients, focusing on peripheral nerve blocks as an alternative or in addition to pharmacological therapy.

Pain measurement scales

Pain should be recorded similarly to the regular documentation of vital signs,[12, 13] but evaluating it can be complex due to the difficulties mentioned above.[10, 14] Usually, pain can be assessed using pain score scales; however, many studies have documented that they are underutilized, especially in polytraumatized patients who may be unable to describe it accurately. Pain-related physiological imbalances may also be masked by inotropic/vasopressor therapy, arrhythmias, and pharmacological interventions.[15] Patient self-reporting of pain is considered the gold standard, and providers should attempt to assess patient-



Item	Description	Score
Facial expression[a]	Relaxed Partially tightened Fully tightened Grimacing	1 2 3 4
Upper limb movements[b]	No movement Partially bent Fully bent with finger flexion Permanently retracted	1 2 3 4
Compliance with mechanical ventilation[c]	Tolerating movement Coughing but tolerating ventilation for most of the time Fighting ventilator Unable to control ventilation	1 2 3 4
BPS score = a + b + c		

BPS

C

Figure 1.—A) Visual Analogue Scales (VAS); B) Numeric Rating Scales (NRS); C) Behavioral Pain Scale (BPS).

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reported pain whenever possible, using objective scales (Figure 1), such as Numeric Rating Scales (NRS), Visual Analogue Scales (VAS), Clinically Aligned Pain Assessment (CAPA), or the Behavioral Pain Scale (BPS).[9, 16]

Unidimensional scales may not accurately reflect the multidimensional nature of the patient's pain experience. The NRS (Figure 1A) is a unidimensional pain assessment tool consisting of an 11-point scale that scores current pain levels from 0 to 10, with 0 indicating no pain and 10 representing the worst imaginable pain. An NRS score between 1 and 3 indicates mild pain, between 4 to 6 signifies moderate pain, and 7 to 10 indicates severe pain.[14] Similarly, in the VAS pain assessment tool (Figure 1B), the patient marks their pain level on a 10 cm line between two points, and a centimeter ruler can be used to measure the level of pain. Next to the most common pain measurement scales, CAPA is a relatively new pain assessment tool that provides a template for a discussion with patients about pain intensity, the effect of pain on function and sleep, and the efficacy of treatment, rather than a score to calculate. When patients are sedated and intubated, pain scales such as the BPS (Figure 1C) have proven to be effective tools to guide analgesic regimens, using facial expressions, body movements, muscle tension, and ventilator compliance to assess pain.[9]

Pharmacological approach

Opioids

Pharmacological management of acute pain in a polytraumatized patient should involve an individualized multimodal treatment plan. Opioids have traditionally represented the gold standard of pain treatment when pain is not adequately controlled with non-opioid medications. Reasons for the judicious use of opioids in well-selected patients include their relative safety, multiple routes of administration, ease of titration, reliability, and efficacy.[17] Opioids modulate pain signaling at the level of the brain and spinal cord through the mu receptor, in a manner similar to endogenous opioid peptide ligands.[14] Morphine, a pure mu agonist, is most commonly used in emergencies for severe pain in Europe, but other opioids, such as fentanyl and oxycodone, are also commonly used.[17, 18] Opioids are primarily metabolized in the liver but, to a lesser extent, can be metabolized in the kidneys, small intestine, lungs, and placenta. Caution should be exercised when considering their use in patients with renal or hepatic impairment.[17] Opioids are associated with significant rates of serious adverse events (addiction, abuse, respiratory depression), leading to longer hospital stays, higher costs, and increased mortality.[18] All opioids produce clinically relevant physical dependence, even with relatively short-term administration.[19] Injured patients are more likely than non-injured patients to become persistent opioid users, and traumatic injury is an independent risk factor for developing persistent opioid use.[20] Less dangerous adverse reactions include nausea, vomiting, hypotension, bradycardia, and skin rash. Long-term adverse effects encompass immune system dysfunction and opioid-induced hyperalgesia. The use of opioids in polytraumatized patients, especially those with traumatic brain injury, may interfere with neurological assessment and pose a risk of causing respiratory depression, hypercapnia, and hypoxia.[21]

Although total pain relief is not practically achievable, multimodal pain management techniques, involving the administration of two or more drugs with different relieving mechanisms, can provide adequate analgesia. Due to the limitations and adverse effects mentioned above, the use of opioids should be reserved for patients with moderate to severe pain in the context of a multimodal approach that combines two or more drugs with different relieving mechanisms to provide adequate analgesia while limiting side effects.[22]

Opioid alternatives

Non-opioid analgesics are essential components of the multimodal approach, reducing the risk of opioid addiction and associated side effects. Commonly used non-opioid analgesics include acetaminophen (paracetamol) and non-steroidal anti-inflammatory drugs (NSAIDs). Acetaminophen and/or NSAIDs are often employed as first-line therapy for mild to moderate pain, with the route of administration typically being oral or intravenous (IV).

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Acetaminophen

Acetaminophen is a weak analgesic with effects on central COX-3 receptors.[9] It is likely best administered as a scheduled medication rather than as needed. High doses of acetaminophen are linked to liver injury; a rational safe maximum dose is 4 g per day, while under healthcare provider supervision, instead, cirrhotic patients should receive a maximum of 2 g per day.[20] In a double-blind study, acetaminophen was found to be non-inferior to diclofenac as an analgesic for acute and mild musculoskeletal trauma pain. However, acetaminophen lacks the anti-inflammatory properties of NSAIDs.[14]

Nonsteroidal anti-inflammatory drugs (NSAIDs)

NSAIDs, such as Ibuprofen, Diclofenac, and Naproxen, are commonly used for pain management in polytraumatized patients.[23] NSAIDs work by inhibiting cyclooxygenase enzymes 1 (COX-1) and cyclooxygenase enzymes 2 (COX-2), thereby inhibiting prostaglandin synthesis. In some studies, they appear to be equally effective as opioids for acute traumatic pain in adults and children.[12] However, side effects of NSAIDs include gastritis, gastrointestinal bleeding, acute kidney injury, and cardiovascular events. In particular, COX-2 selective NSAIDs are associated with an increased risk of myocardial infarction, heart failure and stroke and they should be prescribed at the lowest effective dose and stopped in the shortest time feasible.[24] Most risks are associated with long-term use.[14] It must be remembered that the bleeding time will be prolonged until the NSAID has been excreted.[25] Antiplatelet effects occur primarily through COX-1 inhibition; therefore, COX-2 selective NSAIDs (*e.g.*, Celecoxib) have a reduced risk of inhibiting platelet aggregation.[14] Combination therapy of NSAIDs and Acetaminophen together approximately doubles their opioid-sparing analgesic effect[26] and provides better pain relief than either single agent.[27] NSAIDs are a feasible alternative for controlling mild/moderate pain alone or as part of a multimodal approach in severe pain to reduce opioid dosing and associated adverse effects. NSAIDs should be used with caution in the elderly (due to the risk of peptic ulcer disease), women who are experiencing fertility issues, and asthmatic patients prone to worsening bronchospasm.[28]

Multimodal approach

The multimodal approach to pain in a polytraumatized patient may be more effective than using opioid-only analgesia systems.[9] The Italian Intersociety Recommendations on pain management in the emergency setting suggest minimizing the use of opioids in favor of non-opioid analgesic drugs.[21] A multimodal pain control regimen is a strategy employing a combination of two or more drugs and techniques, as well as non-pharmacological interventions, aiming to provide more effective synergistic analgesia, allowing the use of lower and safer doses of each drug.[29, 30] The in-depth understanding of the mechanisms of action of the various pharmacological principles allows us to leverage their synergies of action for better clinical effectiveness, achieving the best efficacy/safety balance. Numerous clinical practice guidelines recommend multimodal strategies, considering patient-specific factors to guide the selection of the optimal regimen. Pain management guidelines issued jointly by the American Pain Society, the American Society of Regional Anesthesia and Pain Medicine, and the American Society of Anesthesiologists strongly recommend the use of multimodal analgesia in children and adults. Furthermore, growing evidence in the literature supports an expanded role for regional anesthesia (RA) in managing pain associated with trauma casualties.[31, 32] The widespread use of ultrasound and the abundance of educational materials have made learning and successfully performing peripheral nerve blockade more accessible.[33]

For these reasons, this review aims to discuss ultrasound-guided regional anesthesia as an alternative or as part of the multimodal approach to pain in polytraumatized patients. Regional anesthesia offers superior analgesia, attenuation of the stress response, increased alertness, patient cooperation, and the avoidance of systemic side effects. It facilitates ease of transport, provides chronic pain protection, and may improve outcomes in such patients.[3, 33] In the last part of the

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review, we will discuss specific considerations and controversies linked to regional anesthesia in the pain management of polytraumatized patients.

Upper limb trauma

The management of pain affecting the upper limb in polytraumatized patients can be achieved through the use of regional anesthesia, which involves the blockage of the brachial plexus at various levels along the course of its roots. This method effectively delivers anesthesia to the upper extremity, covering from the shoulder to the fingertips. Adequate anatomical recognition and operator experience are essential for the success of anesthesia and ensuring patient safety.[10]

Brachial plexus

The anatomy of the brachial plexus includes six anatomical structures: nerve roots, trunks, divisions, cords, and terminal branches. The nerve roots originate from the vertebral bodies C5 to T1. The terminal nerve branches are the median nerve (formed by the medial and lateral cords), ulnar nerve (formed by the medial cord), radial nerve, and musculocutaneous nerve, which branches from the lateral cord and pierces the coracobrachialis muscle in the proximal axilla (Figure 2A).[34]

The brachial plexus can be blocked at different levels (Table I): interscalene (IS), upper trunk (UT), supraclavicular (SC), infraclavicular (IC), and axillary (AX). The interscalene block provides surgical analgesia/anesthesia from the distal end of the clavicle to the shoulder joint and proximal humerus.[35, 36] The upper trunk block is a nerve-sparing modification of the interscalene block. Supraclavicular, infraclavicular, and axillary blocks provide surgical analgesia/anesthesia from the mid-humerus to the fingertips.[35, 37] They can also serve as an alternative method for shoulder reduction, offering prolonged post-reduction analgesia.[3]

In the case of distal trauma (for example, wrist trauma), peripheral nerve ultrasound blocks are an effective, feasible, and safe option.[38, 39] The advantages of peripheral upper limb block approaches include the distance from critical structures such as the pleura, vessels, and the phrenic nerve.[40] Risks associated with brachial plexus blocks mainly involve injury to nearby vascular structures, phrenic nerve paralysis, and pneumothorax.[34] Ultrasound has made these blocks more accessible and safer to perform, reducing complications, minimizing the total volume of anesthetic required, and enhancing the success of the block itself.

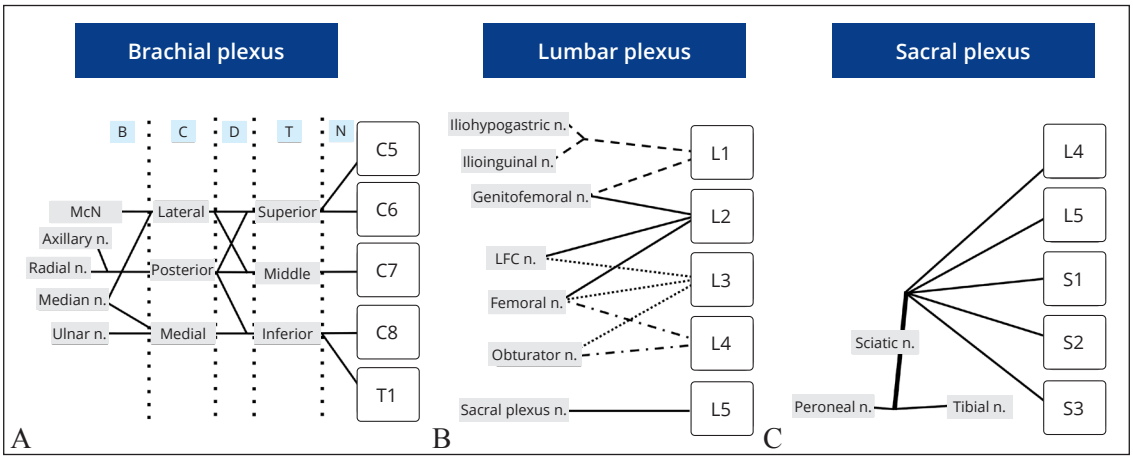

Figure 2.—Anatomy of the brachial plexus (A), lumbar plexus (B), and sacral plexus (C).
N: nerves; T: trunks; D: divisions; C: cords; B: branches; McN: musculocutaneous nerve; C5: cervical spinal nerve 5; C6: cervical spinal nerve 6; C7: cervical spinal nerve 7; C8: cervical spinal nerve 8; T1: thoracic spinal nerve 1; LFC n.: lateral femoral cutaneous nerve; L1: lumbar spinal nerve 1; L2: lumbar spinal nerve 2; L3: lumbar spinal nerve 3; L4: lumbar spinal nerve 4; L5: lumbar spinal nerve 5; S1: sacral spinal nerve 1; S2: sacral spinal nerve 2; S3: sacral spinal nerve 3.

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TABLE I.—*Summary of nerve block for pain control in polytraumatized patients.*

Regional technique	Indications	Complications
Interscalene block	Anesthesia from distal end of the clavicle to the shoulder joint and proximal humerus	Ulnar sparing Phrenic nerve paralysis Horner's Syndrome Artery Injection
Supraclavicular block	Anesthesia to mid humerus to fingers	Pneumothorax Ulnar sparing
Infraclavicular block	Anesthesia of elbow to fingers	Neurovascular injury
Axillary block	Anesthesia of elbow to fingers	Hematoma Neurovascular injury
Lumbar plexus block	Total anesthesia for lower limb	Lateral position Difficult control bleeding
Femoral nerve block	Anterior thigh procedures/medial leg and foot/portion big toe	Neurovascular injury
Obturator nerve block	Hip and medial thigh procedures	Neurovascular injury
Lateral femoral cutaneous nerve block	Hip surgery (analgesia to skin over the lateral thigh)	Variable distribution
Sciatic block (para sacral/ sub gluteal)	Posterior thigh/knee surgery	Difficult to visualize. Not cover medial aspect lower leg
Sciatic block (popliteal)	Ankle/forefoot surgery	Not cover medial aspect lower leg
Ankle block	Forefoot/midfoot surgery	Multiple injections required
Serratus block	Posterolateral thorax anesthesia (rib fractures)	Pneumothorax

Regional anesthesia techniques for upper limb trauma

To perform a US-guided interscalene brachial plexus block, place the transducer in the supraclavicular fossa in a transverse orientation transverse to the neck. Identify the subclavian artery and the divisions of the brachial plexus, which appear as hypoechoic circular structures resembling "grapes." Move the transducer cephalad to identify the C5 and C6 roots, which appear as hypoechoic round structures (Figure 3A). C6 often exhibits a split, forming the commonly referred-to "stoplight sign."[41] Insert the needle using an in-plane US approach, advancing the needle tip between the C5 and C6 nerve roots. After negative aspiration, inject the local anesthetic.

In the case of a US brachial plexus block at the clavicular level, the transducer should be placed medial to the coracoid process, parallel to the clavicle. Visualize the axillary artery and vein. The lateral, medial, and posterior cords of the brachial plexus appear as hyperechoic structures containing hypoechoic nerve fascicles, creating a

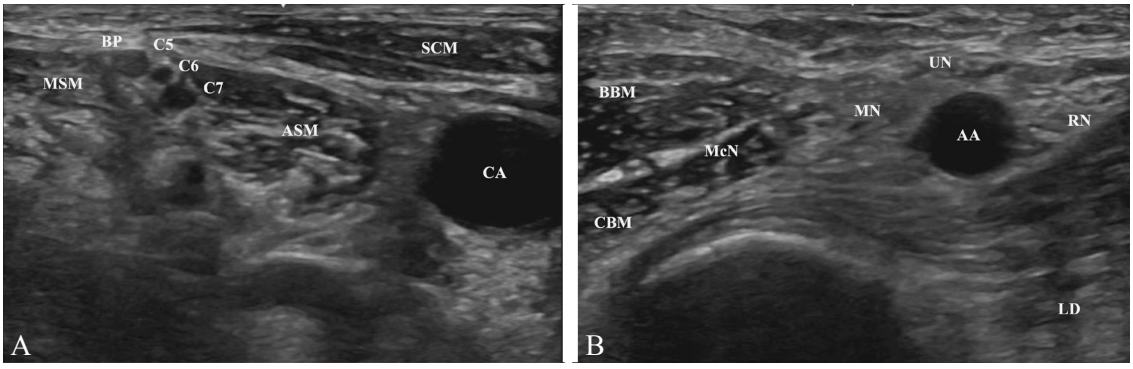

Figure 3.—Ultrasound anatomy for an interscalene brachial plexus block (A) and for axillary brachial plexus block (B). BP: brachial plexus; MSM: middle scalene muscle; ASM: anterior scalene muscle; SCM: sternocleidomastoid; CA: carotid artery; C5: cervical spinal nerve 5; C6: cervical spinal nerve 6; C7: cervical spinal nerve 7; AA: axillary artery; McN: musculocutaneous nerve; MN: median nerve; UN: ulnar nerve; RN: radial nerve; CBM: coracobrachialis muscle; BBM: biceps brachialis muscle; LD: latissimus dorsi.

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"honeycomb" appearance. After negative aspiration, inject a local anesthetic.

To perform a US axillary brachial plexus block, place the ultrasound transducer at the level of the axilla, identifying the axillary artery. Around it, locate the median (usually in the lateral quadrant), ulnar (usually in the medial superficial quadrant), and radial (usually in the medial deep quadrant) nerves as hyperechoic structures (Figure 3B). Insert the needle using an in-plane US approach and, after negative aspiration, inject the local anesthetic next to the nerves. For more distal and selective blocks, move the transducer proximally to the mid-forearm and identify the radial nerve lateral to the radial artery. To perform a median nerve block, visualize it between the tendons of the flexor palmaris longus (between the flexor carpi ulnaris and radialis tendons) and the flexor carpi radialis. For an ulnar nerve block, identify the ulnar artery, with the ulnar nerve located medially to this vessel.[42]

Lower limb trauma

The management of pain affecting the lower limb in trauma patients can be achieved through the use of regional anesthesia by blocking the lumbosacral plexus (Figure 2B, C). This plexus is responsible for the innervation of the entire lower limb, including the nerve roots from L1 to S4, and it is divided into the femoral, lateral femoral cutaneous (LFCN), obturator, and sciatic nerves. The femoral nerve provides sensory function to the anterior thigh, medial leg, and foot, as well as a portion of the big toe. The LFCN provides sensation to the lateral thigh, the obturator nerve provides sensation in the medial part of the thigh, and the sciatic nerve provides sensory innervation to the posterior thigh. Distally, the sciatic nerve divides into the common tibial and peroneal nerves, which provide sensory innervation to the anterior, lateral, and posterior lower legs.[43]

A multimodal pain approach to lower limb pain after polytrauma can be achieved through various regional anesthesia techniques (Table I). Techniques such as femoral nerve block or fascia iliaca compartment block are effective for alleviating pain from hip and proximal femur fractures.[43-46] The pericapsular nerve group block (PENG) is an innovative regional anesthesia technique providing analgesia for hip fractures. It targets the joint branches of the femoral, obturator, and obturator accessory nerves, innervating the anterior capsule of the hip.[43]

In the case of knee pain, a combined block of the femoral nerve, in association or not with the block of the sciatic nerve, seems to be the best choice.[38] An emerging regional anesthesia technique (iPACK), blocking the interspace between the popliteal artery and the posterior knee capsule, allows you to cover pain in the back of the knee, filling the gaps left by other regional anesthesia techniques.[43] For fractures of the tibia and fibula, the options of choice are, therefore, the sciatic/tibial nerve block. For ankle pain, the options of choice are combined distal sciatic and femoral/saphenous nerve block.[43, 47]

Regional anesthesia techniques for lower limb trauma

The lumbar plexus block simultaneously blocks the LFCN, the femoral nerve, and the obturator nerve.[43] However, this block has limitations as it requires lateral positioning of the patient, which is not always possible, and does not allow easy control of bleeding as it is a deep block, close to the epidural spaces.[38] Ultrasounds are essential to identify the transverse process and psoas muscle and to determine the depth of needle insertion.[48] The lumbar plexus is not usually visualized directly with ultrasound, lying deep in the posterior one-third of the psoas major muscle, though it. Local anesthetic (LA) is injected into the psoas compartment, and its spreading within the muscle should be observed.[49]

In the femoral nerve block performed with ultrasound, the transducer should be placed on the anterior leg transverse to the femur at the level of the inguinal crease. Next, the femoral artery should be identified, and laterally, the femoral nerve appears as a hyperechoic structure immediately deep to the fascia iliaca, and superficial to the iliopsoas muscle (Figure 4A).[50] The sciatic nerve block can be performed either through an anterior or a posterior approach, with similar success rates. In the posterior approach, the nerve can be blocked in a transgluteal way (the transducer should be

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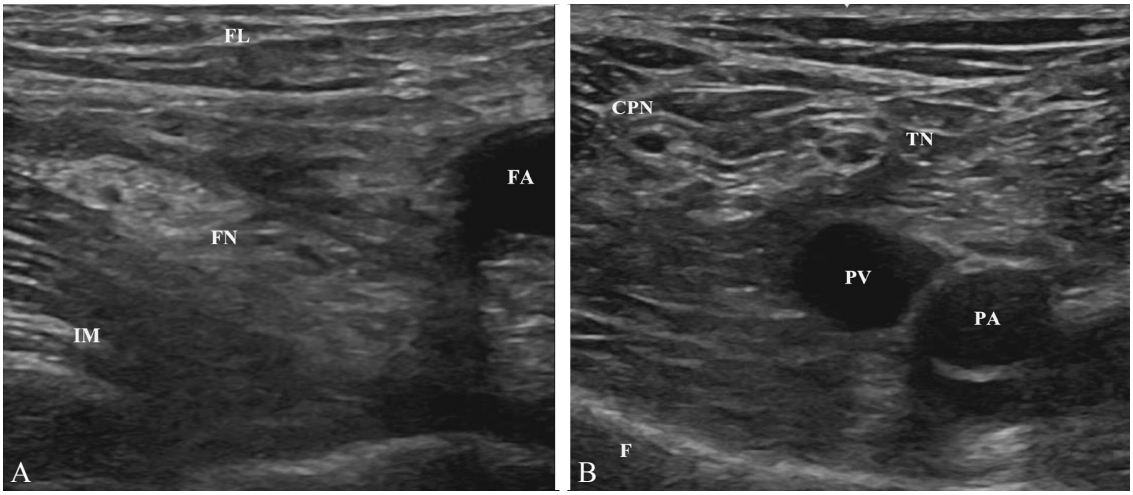

Figure 4.—Ultrasound Anatomy for a femoral (A), tibial, and common peroneal nerve block (B).
FA: femoral artery; FN: femoral nerve; IM: iliacus muscle; FL: fascia lata; TN: tibial nerve; CPN: common peroneal nerve; PV: popliteal vein; PA: popliteal artery; F: femur.

placed midway between the greater trochanter and the posterior superior iliac spine in an orientation transverse to the course of the nerve) or in an infragluteal way (the transducer should be placed midway between the greater trochanter and the ischial tuberosity in an orientation transverse to the course of the nerve). In both cases, the sciatic nerve appears hyperechoic, flat, and wide between the gluteus maximus muscle and quadratus femoris maximum (in a transgluteal way) and between the gluteus maximus muscle and adductor magnus muscle (in an infragluteal way).[51, 52] In the anterior approach, the US probe should be placed transversely on the proximal medial thigh, and the sciatic nerve appears hyperechoic under the adductor magnus muscle at a depth of 6-8 cm.[53] In the case of isolated trauma to the foot, the sciatic nerve can be blocked distally at the level of the popliteal crease (Figure 4B).

Rib fractures and thoracic trauma

Effective analgesia for polytrauma patients with rib fractures after polytrauma is the primary goal of their management, as surgical fixation is generally not performed in most cases.[54] The innervation of the thoracic cage belongs to the intercostal nerves. Thoracic epidural analgesia (TEA) or thoracic paravertebral block (TPVB) is usually considered the first line in pain management after chest wall trauma.[55] The Eastern Association for the Surgery of Trauma (EAST) recommends that epidural analgesia may improve outcomes (Grade B recommendation) and that it should be considered the preferred analgesic modality (Grade A recommendation).[56] The disadvantages of TEA include technical complexity, as the placement of an epidural catheter may be challenging in an awake trauma patient experiencing acute pain. This complexity can result in an increased risk of dural puncture, spinal cord injury, hypotension, and motor block.[57] Alternative choices for pain management TPVB, intercostal nerve block,[58] serratus plane block (SPB), and erector plane block (ESP). These alternatives offer a level of analgesia comparable to TEA but with fewer side effects and complications.[59-61]

The TPVB provides targeted unilateral and sympathetic segmental thoracoabdominal somatic analgesic block without compromising neurological assessment.[3] The risks of the technique are generally small and include contralateral spread via the epidural space, pneumothorax, hypotension, and vascular puncture. Intercostal blocks provide good pain control but have a limited duration of action and suffer from a major risk of pneumothorax. Intrapleural block with a local anesthetic has similarly limited efficacy

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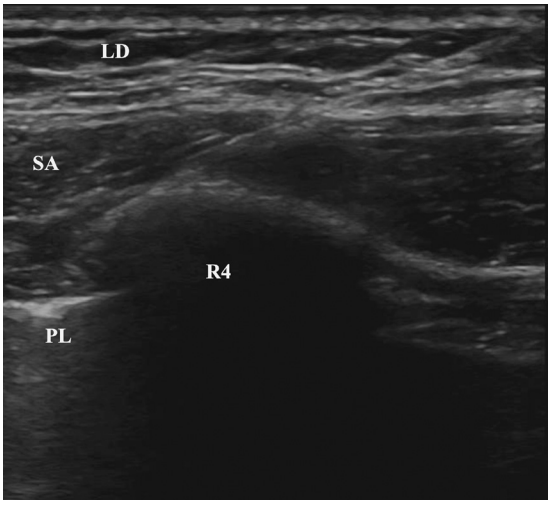

Figure 5.—Ultrasound anatomy for a serratus anterior plane block.
D: latissimus dorsi; SA: serratus anterior muscles; PL: pleura; R4: fourth rib.

and carries a high risk of rapid systemic absorption of the local anesthetic.[62]

Ultrasound-guided serratus anterior plane block (SAPB) targets the lateral cutaneous branches of the thoracic intercostal nerves, thus providing analgesia from the T2–T9 dermatomes of the anterolateral thorax (Table I, Figure 5). Due to the ease of structure identification, the block has been widely used for pain management in thoracic trauma, including rib fractures, especially at the posterolateral level.[54, 63] The erector spinae block (ESP) is simple to perform and relatively safe. The target is superficial to the transverse process, and the needle tip remains distant from the pleura and major vessels. The ESP block delivered an improvement in pain scores and respiratory parameters in patients suffering from traumatic rib fractures.[61, 64]

Disputes about nerves blocks

Acute compartment syndrome (ACS)

ACS is a rare but dangerous consequence of a traumatic injury. In ACS, the pressure within a closed muscle compartment increases and exceeds the capillary perfusion pressure. This compromises the circulation and tissue function within that space. Symptoms include paresthesia, pain disproportionate to the lesion and distal to the surgical site, and motor weakness.[38] The definitive treatment is decompression.[3] Over a third of all ACS cases are associated with tibia fractures, particularly in the proximal and middle third of the diaphysis, and less frequently with forearm fractures.[62]

Regional anesthesia techniques have been implicated as a potential cause of delayed ACS diagnosis.[3] However, it has been observed that regional anesthesia can aid in diagnosis. Each new pain during a continuous peripheral nerve block, with low AL dosage, in monitored patients, can serve as an alarm signal for possible complications.[65] This approach aims to achieve effective analgesia and diagnostic capacity for ACS.[38] Vigilance by the surgical and anesthetic teams involved in patient care is crucial for early diagnosis.[62, 65]

Acute peripheral nerve injury

Peripheral nerve injury is considered an additional risk in regional anesthesia techniques. In polytraumatized patients the incidence of peripheral nerve injury is increased due to either the compression of the nerve or the trauma-related vascular mechanism. A retrospective study conducted by Yin *et al.* found no differences in the number of events of nerve dysfunction after acute nerve injury repair between subjects undergoing peripheral nerve block and those undergoing general anesthesia.[66] Anyway, the risk can be minimized by using low doses of AL, employing atraumatic needles, and maintaining low injection pressure. It is crucial to conduct a thorough neurological examination before and after both regional anesthesia and surgery.[38]

Patient positioning

Polytraumatized patients may face limitations in positioning due to the risk of exacerbating medullary lesions. For example, lateral or prone positioning for lumbar plexus blocks and the posterior approach for the sciatic nerve block might be avoided. Additionally, the cervical collar poses a limitation, preventing access to the supraclavicular region and, therefore, hindering the performance of blocks in this area.[38]

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Conclusions

In trauma patients, pain should be identified and recorded as a "vital sign," and opioids represent the gold standard of treatment. Growing evidence in the literature supports a greater role for ultrasound-guided regional anesthesia. The classical pharmacological approach, combined multimodally with ultrasound-guided locoregional anesthesia, allows for the reduction of drug-related side effects and ensures better pain control in polytraumatized patients. Major concerns when performing peripheral nerve blocks in polytraumatized patients include acute compartment syndrome, acute peripheral nerve injuries, positioning limitations, and operator expertise.

Key messages

- In trauma patients, pain should be identified and recorded as a "vital sign."
- Opioids represent the gold standard of pain treatment in polytraumatized patients.
- Ultrasound-guided regional anesthesia plays a pivotal role in pain control for trauma patients.
- Various types of peripheral nerve blocks can be employed to control pain based on the location of the trauma.

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Conflicts of interest

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Authors' contributions

Cesare Biuzzi and Daniele Marianello contributed equally to this study. Cesare Biuzzi and Charlotte Wellens have given substantial contributions to the conception, writing of the manuscript, acquisition, analysis, and interpretation of the data. Daniele Marianello and Francesca Remiddi contributed to drafting the rib fractures and thoracic trauma section. Agnese Di Chiaro, Benedetta Bidi and Daniele Marianello contributed to drafting the upper and lower limb sections. Cesare Biuzzi realized the figures and Charlotte Wellens realized the table. Sabino Scolletta and Federico Franchi revised it critically. All authors read and approved the final version of the manuscript.

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